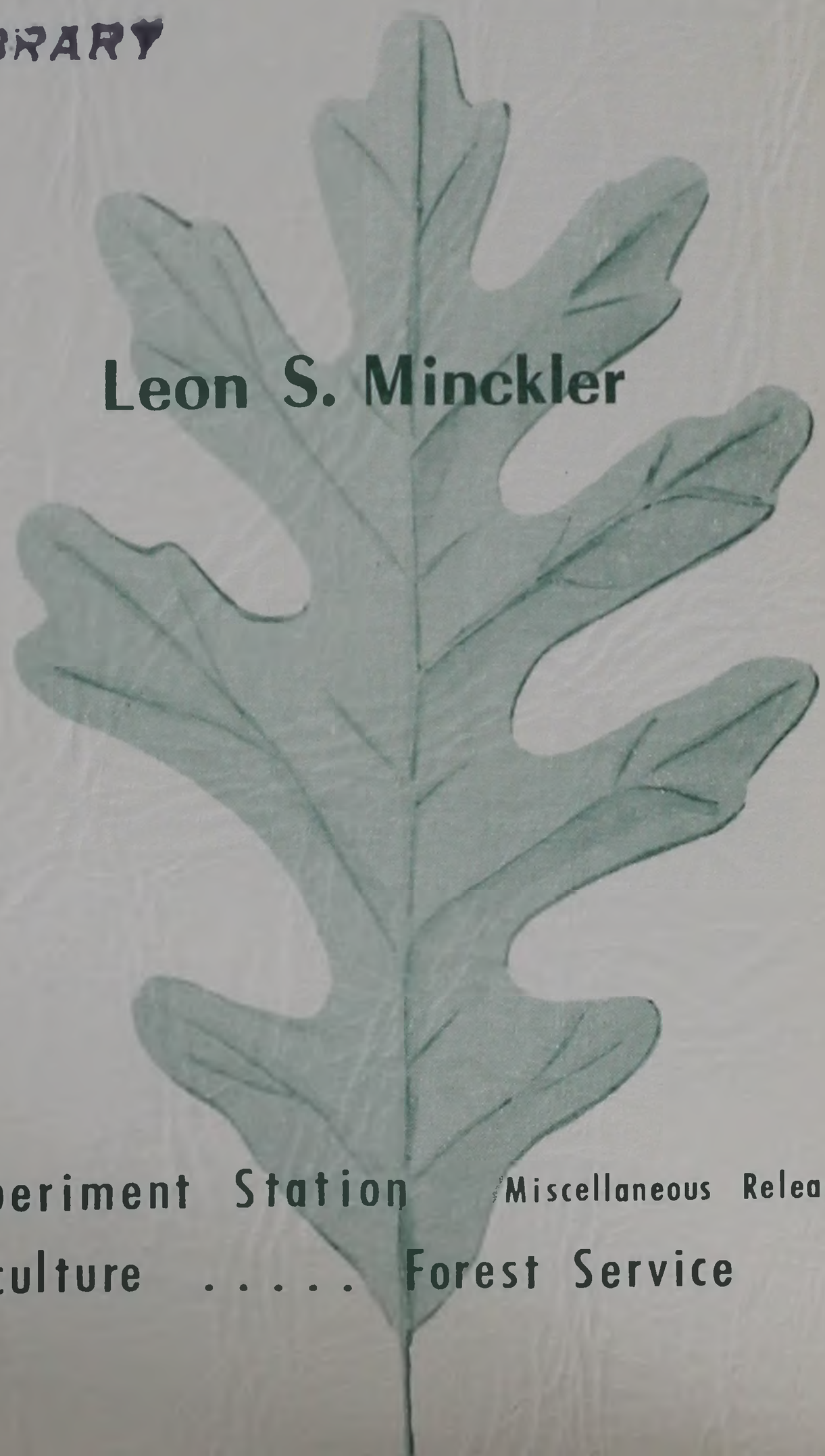
SILVICAL CHARACTERISTICS of WHITE OAK



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Where climate and soil are favorable for germination and growth, white oak usually reproduces adequately from seed if: (1) There are large seed trees within about 200 feet; (2) there is a light to moderate (but not thick) litter cover; and (3) there is full sunlight at least part of the day (24). Minimum sunlight needed for good seedling growth is about 30 percent.

Silvicultural practices that favor the establishment of white oak seedlings include: The creation of openings large enough to allow adequate light; (2) elimination of overtopping competition; (3) preservation of a light litter; and (4) leaving a good stocking of seed-bearing trees. In general, this means a group selection cutting or a three-cut shelterwood system combined with weedings as necessary, and protection from fire and grazing. Such measures will not, however, always result in good reproduction, especially outside the optimum range or on sites better suited for other species.

Soil moisture is probably the most important factor affecting early survival of seedlings. Yet, in one study (9), white oak was relatively insensitive to moisture in the top 12 inches of soil when compared with shortleaf pine, sweetgum, and dogwood. When available soil moisture was only 19 percent, white oak seedling survival was 98 percent; at 3 percent available soil moisture survival was 87 percent. The long taproot that develops early probably enabled the seedlings to obtain moisture from deeper soil. White oak did make more total growth on plots where all competition was eliminated but the effect of competition was significantly less than for the other species. White oak is considered to be less demanding than other climax species in the struggle for early survival (9)

On better sites white oak outgrows dry-site species like post and blackjack oak. On the driest sites, however, post and blackjack oak prevail because they are less susceptible to drought injury than white oak (1).

Shoot growth and leafing out of white oak starts from mid-March to late May, depending on latitude. It usually occurs a little later than on yellow-poplar and black and red oaks. Most of the height growth occurs during the spring. One study shows that 50 percent of the seedling height growth occurred in April and growth was 90 percent completed by July 1 (16). In these tests white oak grew faster than northern red oak but slower than yellow-poplar and white ash. On poor sites in the Ozarks white oak seedlings grew 3.1 inches per year and stool sprouts grew 6.5 inches (19). On good sites it is not uncommon for larger oak seedlings to grow 2 feet or more in height each year.

Figure 1.--Virgin white oak stand in Indiana averaging 32,000 board-feet per acre.

Sapling Stage to Maturity

Growth Rate and Yield

White oak generally has the reputation of being a slow-growing tree. This is only partly deserved. Early growth may be slower than some associated species and under certain conditions white oak trees may become overtopped. Overtopped trees, however, will persist for a long time. When not overtopped, white oak grows faster in height than associated hickories, nearly as fast as black oak and red oak, but somewhat slower than yellow-poplar.

Diameter growth follows a similar pattern. In the Tennessee Valley (5) white oak sawtimber-sized trees grew slower than yellow-poplar and scarlet oak, about the same as black oak, and faster than hickory. State averages from Forest Survey data on white oak in the Central States range from 1.4 (Missouri) to 2.1 (Indiana) inches diameter growth in 10 years. The average of 1.8 for all states was about the same as black oak, slightly less than scarlet oak, 6/10 of an inch less than yellow-poplar, but 4/10 of an inch greater than hickory.

White oak normally occurs in mixed, uneven-aged stands. Even-aged mixed oak or pure white oak forests, however, do occur after clear cutting. Individual trees may contain 1000 board-feet or more but this is not common. Pure and mixed stands will normally contain from 2,000 to 12,000 board-feet per acre, occasionally more. Except on the poorest sites, growth of managed stands will vary from 150 to 600 board-feet per acre per year with a rotation of 80 to 100 years for sawlog production. Unmanaged stands may yield much less.

Fully stocked, "normal" even-aged stands of mixed oak are reported to yield 6,380 cubic feet at age 100 on site index 80 (28) and on very good sites in Wisconsin 21,000 board-feet at age 100 (11). However, such high yields are rare and occur only in localized areas. The poorest sites yielded about 1/5 to 1/3 as much.

Reaction to Competition

White oak is generally considered intermediate in light tolerance (30). It is more tolerant in youth, less tolerant as the tree becomes large. In one study (17), white oak seedlings were still vigorous after 4 years under a forest canopy, better in this respect than dogwood. Overtopped, pole-sized trees may be 100 years old and still have vigorous crowns (25). In the central hardwood forests it is more tolerant than the black and red oaks, much more tolerant than yellow-poplar, but slightly less tolerant than the hickories, elm, and blackgum.

In one study (25), white oak pole-sized trees increased diameter growth the first year after complete release and continued the second year at a faster rate. Only heavily suppressed trees with malformed and low-vigor crowns failed to respond equally well. Saplings of intermediate crown class have also responded well to release (6). This shows that good quality white oak saplings and poles may be released and thinned from above because good growth response is almost immediate.

White oak usually tends to become dominant in the stand, at least in its optimum range. Reasons for this are: (1) Its ability to live vigorously for long periods as an overtopped tree; (2) its ability to respond quickly to release; (3) its moderately fast growth rate in full sunlight; and (4) its great longevity.

Natural pruning of white oak is usually good in moderate to heavily stocked stands. Large, dominant trees usually have cleaner boles than smaller trees in lower crown classes. There is a tendency for some branches along the trunk to persist if strong side light is present. Epicormic sprouting may be heavy on suddenly released trees, especially if they were slow-growing (3). Large, vigorous trees seldom develop epicormic branches when exposed to full light but branches already present will persist and increase in size.

Live branches not more than 1 1/2 inches in diameter may be saw-pruned without danger of introducing rot (26). However, epicormic sprouts usually develop around the edges of the wound, so the practice is of doubtful value.

Climax Position

White oak, when associated with other oaks and hickory in the central and southern hardwood forests, is considered a climax species (2, 29). On good sites in the north it is usually succeeded by sugar maple types. Pure white oak is also a climax type, usually on drier sites than the mixed types. In sheltered moist coves and well-drained second bottoms throughout its range, white oak may be succeeded by beech and other more tolerant species.

ENEMIES AND HAZARDS

Insects

Several insects attack white oak trees. They are usually not important but may become epidemic under certain conditions and can be fatal to weakened trees. Economically the most important are the various wood borers. These may damage the wood of standing trees and thus cause log and lumber defects. There are several white oak leaf eaters including the gypsy moth (Porthetria dispar), and the orange-striped oak worm (Anisota senatoria). White oak is also host to various scale insects, gall-forming insects, and twig pruners. Most of these are of minor importance. The acorns of white oak are commonly damaged by various weevils (Curculio), insect larvae, and gall-forming cynipids (15).

The oak timber worm frequently damages white oak so as to make it unfit for tight cooperage. Attacks by this insect usually occur at wounds made by logging, lightning, and wind.

Golden oak scale can cause serious damage and even death to the tree. It is especially damaging when accompanied by drought.

Diseases

Decay of heartwood resulting from fire scars causes the most serious losses in white oak. The amount of decay following basal fire scars depends upon: (1) The size of the wound, (2) the species of fungi involved, and (3) length of time since wounding (13). In general, rot continues to increase if the basal scar is more than a foot in diameter. The larger the wound the faster the increase of rot. Smaller wounds cause little butt rot. Heart rot may also enter the tree through insect holes.

Oak wilt, a vascular disease caused by the fungus Ceratocystis fagacearum, is potentially the most destructive disease of both red and white oaks. It is widely distributed throughout the Central States but so far only a few trees have been killed. The disease is spreading, however, and an epidemic would deal a fatal blow to the oak-using industry and a critical blow to hardwood forestry in general.

Several other diseases of white oak are of relatively minor importance and seldom cause death or much loss. They are as follows:

Cankers: Of the various bark diseases, perennial cankers induced by Strumella coryneoidea and Nectria galligena are responsible for most of the losses in white oak. Damage results from a weakening of bole at the cankers and subsequent wind breakage, or the trunk becomes wholly or partially unmerchantable.

Shoestring root rot: A root rot caused by the fungus Armillaria mellea occurring on weakened trees; not important under natural forest conditions. Clitocybe mushroom root rot, caused by Clitocybe tabesceus, is similar and attacks oaks in the South. White root rot, caused by Polyporous dryadeus, is common on weak and suppressed trees.

Anthracnose: A fungus, Gnomonia veneta, which causes irregular brown areas on leaves and shoots. It may cause loss of some leaves and, rarely, complete defoliation.

Leaf blisters: Leaf infections are generally of minor importance. Oak leaf blister, caused by Taphrina coerulescens, is prevalent on eastern oaks, producing blister-like swellings on the foliage.

RACES AND HYBRIDS

In addition to Quercus alba, two varieties are listed (20). These are Quercus alba (var.), repanda Michx. and Quercus alba (var.) latiloba Sarg. The latter occurs more generally in the northern part of the range. At least 6 hybrids with white oak have been discovered and described (20). Others have probably occurred.

No definite races have been defined, but within such a tremendously diverse habitat, climatic races undoubtedly exist. The white oak of Maine is very probably different physiologically from the white oak of northern Florida. The great tendency to hybridization among the oaks probably tends to mask clearcut races.

Artificial hybridization of oaks has not been generally successful (36). Seed-bearing capacity of individual trees varies greatly and selection for fruitfulness may mean negative selection for tree vigor or other desirable qualities.

Figure 2.--Fifty-three-inch white oak in virgin stand in Ohio.

SPECIAL FEATURES

Historically, white oak has been famous for its relatively sweet acorns. American Indians and some early white settlers commonly used boiled white oak acorns for food. They are also a favorite food for hogs and for many kinds of wildlife.

White oak has one of the most variable barks of any tree species. It varies greatly in configuration, color, and texture, depending upon growth rate, age, and condition of the tree.

The unfolding leaves of white oak present a full range of brilliant colors starting with vivid red, turning pink, then to a whitish bloom, and finally to green. On small trees the dead leaves are often retained throughout most of the winter.

TREE SPECIES MENTIONED

White ash	-	*Fraxinus americana* L.
American basswood	-	*Tilia americana* L.
American beech	-	*Fagus grandifolia* Ehrh.
Blackgum	-	*Nyssa sylvatica* Marsh.
Black cherry	-	*Prunus serotina* Ehrh.
Elm	-	*Ulmus* L.
Eastern hemlock	-	*Tsuga canadensis* (L.) Carr.
Hickory	-	*Carya* Nutt.
Sugar maple	-	*Acer saccharum* Marsh.
Black oak	-	*Quercus velutina* Lam.
Blackjack oak	-	*Q. marilandica* Muenchh.
Northern red oak	-	*Q. rubra* L.
Post oak	-	*Q. stellata* Wangenh.
Scarlet oak	-	*Q. coccinea* Muenchh.
White oak	-	*Q. alba* L.
Eastern white pine	-	*Pinus strobus* L.
Loblolly pine	-	*P. taeda* L.
Shortleaf pine	-	*P. echinata* Mill.
Sweetgum	-	*Liquidambar styraciflua* L.
Yellow-poplar	-	*Liriodendron tulipifera* L.

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This is the seventh of a series of 17 papers dealing with the silvical characteristics of forest trees important in the Central States region. The following species are included in this series. (Those marked with an asterisk have already been published.)

*Ohio buckeye
Yellow buckeye
*Northern red oak
*Black oak
Chinkapin oak
*Pin oak
*White oak
Swamp white oak
Bur oak
Butternut
Black walnut
*Shellbark hickory
Sycamore
Honeylocust
Hackberry
Black locust
*Eastern redcedar

Papers covering additional important American species will be issued by other Forest Experiment Stations of the U. S. Forest Service.

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W. G. McGinnies, Director

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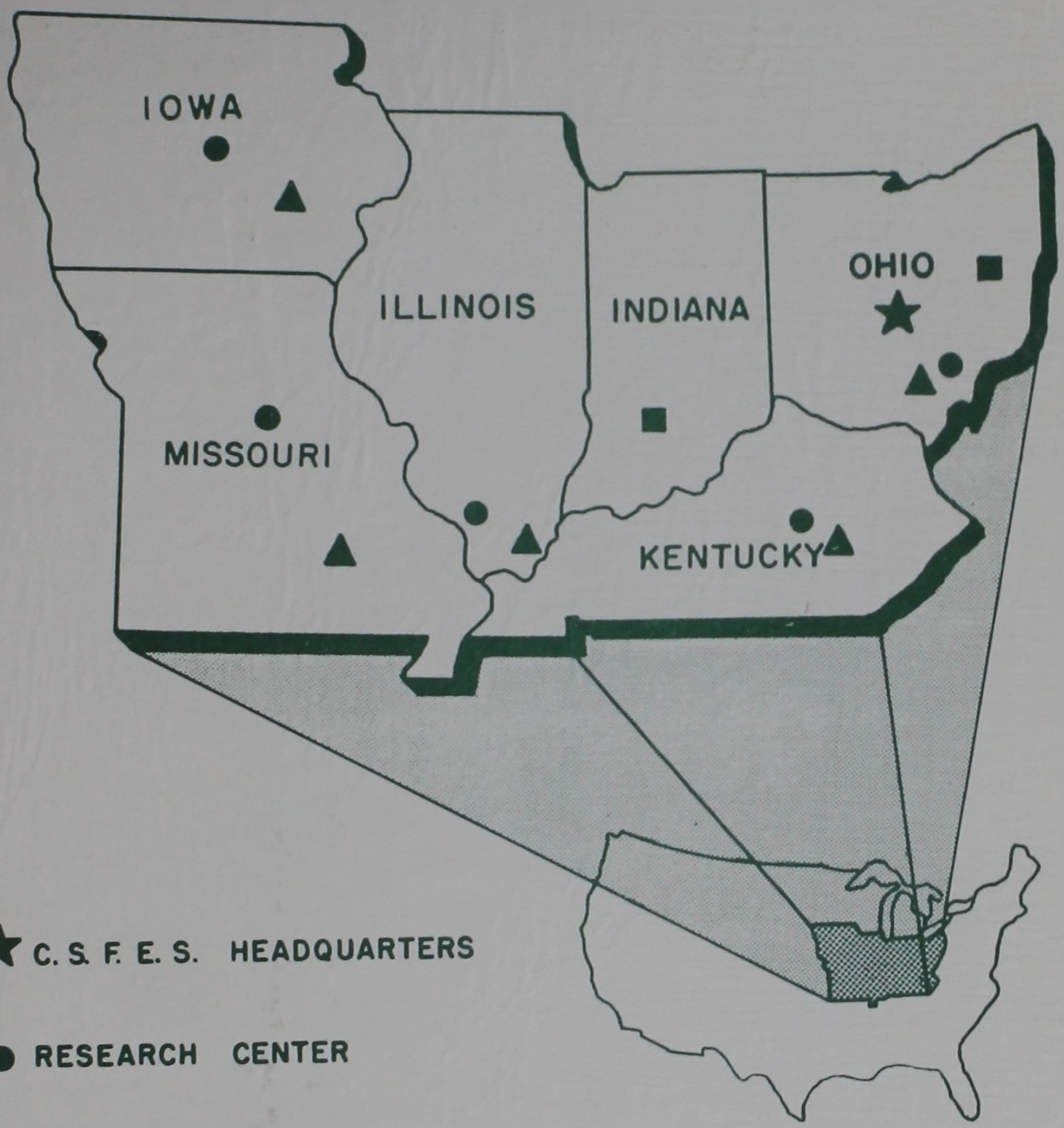

Silvical Characteristics of White Oak

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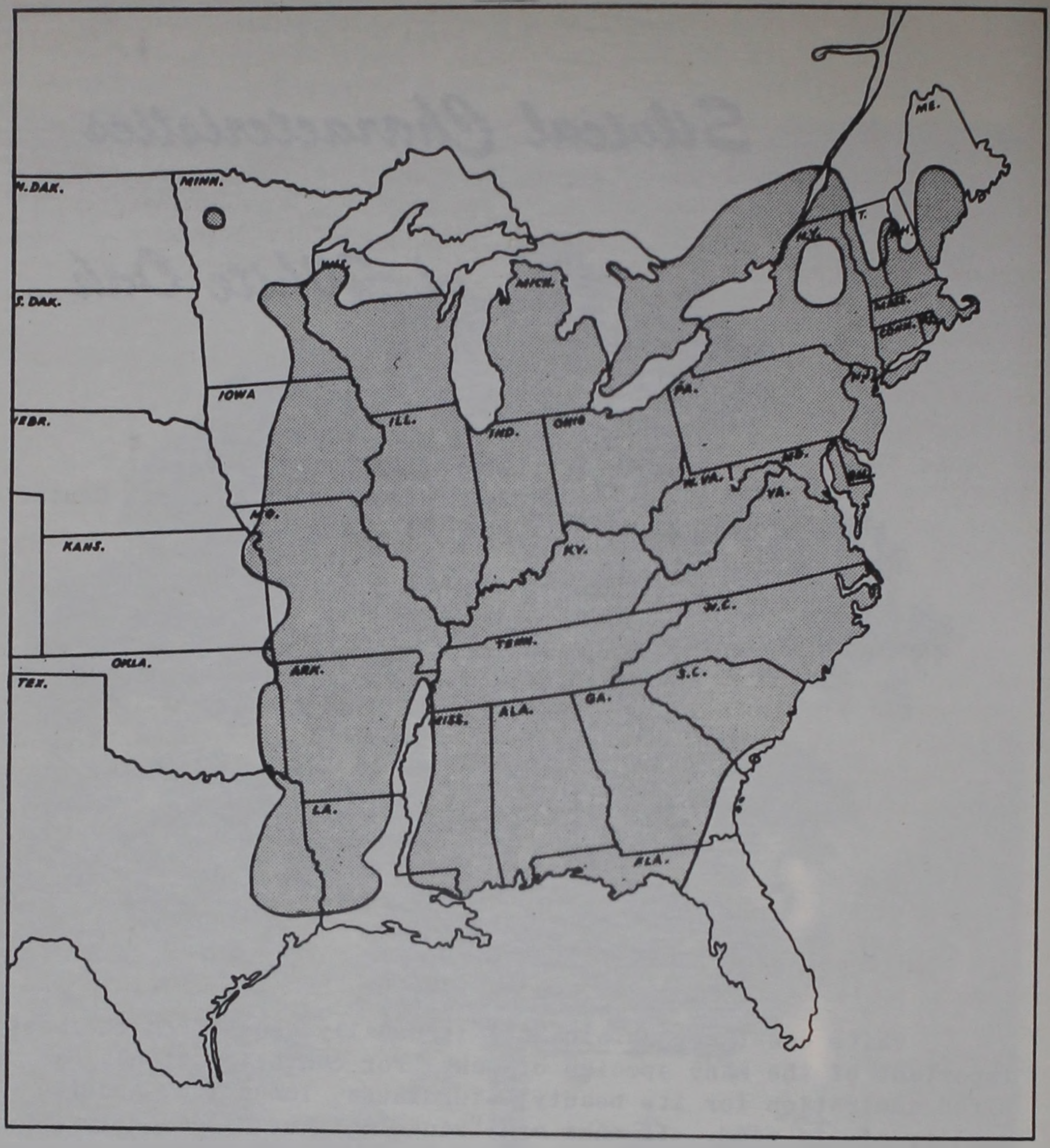
White oak (Quercus alba L.) is usually considered the most important of the many species of oak. For centuries it has excited admiration for its beauty, sturdiness, longevity, and the quality of its wood. If oaks are "kings" of the hardwood forest, then white oak is the "king of kings."

White oak is a large tree normally reaching 100 feet in height and 4 feet in diameter on good sites. Trees 150 feet tall, 8 feet in diameter and 600 years old have been found. In the open white oak develops a short, stocky bole with a very widespreading, robust crown. In the forest it grows tall and straight with a narrow crown.

Other common names for white oak are fork-leaf oak, ridge white oak, and stave oak.

DISTRIBUTION



The range of white oak generally extends from the Atlantic Ocean to the prairie and from Canada to the Gulf of Mexico. The species is generally absent from the coniferous types of the high Appalachians, the Delta region of the lower Mississippi, and the coastal region of Texas, Louisiana, and Mississippi. The optimum commercial range lies on the west slopes of the Appalachian Mountains and in the adjacent Ohio and central Mississippi valleys. However, the largest individual trees have been found in Delaware and on the eastern shore of Maryland (12, 27).[1/]

1/ Numbers in parentheses refer to Literature Cited, p 15.

HABITAT CONDITIONS

Climate

White oak grows in a very wide range of climatic conditions. Mean annual temperature varies from 45° F. along the northern edge of the range to nearly 70° F. in east Texas and north Florida. The extreme low temperature ranges from -50° F. in Wisconsin and Minnesota to zero in north Florida. Precipitation varies from 80 inches per year in the southern Appalachians to 30 inches in southeastern Minnesota. Average annual snowfall is 70 inches in southern Maine and less than 1 inch in northern Florida. The average noon July relative humidity is less than 50 percent in the western part of the range and more than 65 percent on the Atlantic coast. The frost-free season ranges from 5 months in the north to 9 months in the extreme southern part of the range. The mean maximum frost penetration in the soil is 40 inches in the north and 1 inch in the south.

The optimum range of white oak in the Ohio Valley and central part of the Mississippi Valley has about the following average climatic conditions: Annual temperature 55° F.; annual precipitation 40 inches; annual snowfall 15 to 20 inches; noon relative humidity in July 55 percent; frost-free season 6 months; frost penetration 10 inches (2, 33, 35).

Soils

White oak occurs naturally on a very wide range of soils and sites. It is found on some podzols, gray-brown podzolic soils, brown podzolic soils, red and yellow podzolic soils, lithosols, planosols, and alluviums. The species grows on both glaciated and non-glaciated soils derived from a large variety of parent materials (32).

It is found on sandy plains, gravelly ridges, rich uplands, coves, and well-drained second bottoms. Development is best on deep, well-drained loamy soils but growth is good on all except the driest, shallow soils (10).

Mineral nutrition usually does not limit white oak growth except on very sandy soils. In one study (23), the mineral content of leaves was not correlated with that of the A soil horizon. White oak leaves on the most productive soils were only slightly richer in minerals than on the poorest soils. So apparently white oak assimilates sufficient minerals even from the poorer soils.

Physiography

White oak occurs on all upland aspects, slope positions, and ridgetops within its range except extremely dry, shallow-soiled ridges, poorly drained flats, and wet bottomlands. It does best on northerly and easterly lower slopes and coves but grows well on moderately dry slopes and ridges with shallower soils (10, 31). Although of smaller size, on the drier west and south-facing slopes white oak is commonly more abundant here than on the more mesophytic sites (8, 22). In the central and southern parts of its range, altitude is seldom limiting. In the northern part of the range it seldom occurs above 500 feet in elevation. It is practically excluded from the high Appalachians in New York and New England. In the southern Appalachians it grows to an extreme of 4,500 feet altitude as a scrub tree.

Associated Species

White oak is associated with many other species, the more important of which are other upland oaks, hickories, yellow-poplar, American basswood, white ash, black cherry, sweetgum, blackgum, American beech, sugar maple, shortleaf pine, loblolly pine, eastern white pine, and eastern hemlock. The most frequent associates are probably other oaks and the hickories. Of the 26 northern forest types (29), white oak occurs as a chief associate in 7 of them. Of the 33 central forest types, white oak is the type species in 3 (white oak; white oak - red oak - hickory; and yellow-poplar - white oak - northern red oak) and a chief associate in 11 of them. It is also a chief associate in 8 of the 40 southern forest types. It usually occurs in mixed stands but small areas of pure stands are common.

There are no known shrubby or herbaceous indicators for site quality of white oak or the white oak types. There are no animals specifically associated with white oak. However, acorns in general top the list of plant food for wildlife including deer, birds, squirrels, and other rodents. The chief reason is that acorns constitute a relatively good and abundantly available staple (21). White oak acorns are sweeter and usually preferred to those of the black and red oaks. The use ratio of acorns for wildlife is probably higher than for any other food.

LIFE HISTORY

Seeding Habits

Flowers of white oak appear in the spring about the same time as the new leaves. The time may vary from late March to late May, depending upon the latitude. Staminate and pistillate flowers are borne on the same tree. Cross-fertilization between trees is common. Acorns ripen in 6 to 8 months, drop in late September and October, and germinate almost immediately (18, 27).

White oak is often a prolific seeder but good acorn crops are irregular, occurring 4 to 10 years apart. Sometimes several years may pass without a crop. Trees normally bear seed between the ages of 50 and 200 years or more; however, open-grown trees may produce seed as young as 20 years.

The yield of acorns per tree is extremely variable. On three experimental areas in Missouri the average number of mature acorns per tree annually varied from 0 to 1,900 over a 6-year period (4). In one county the annual average number per tree was 1,100 and in another county 700. The best tree had 7,700 acorns per year. Trees were consistently good or poor seed producers from year to year. Crown size was a significant factor in acorn production but inherent differences tended to obscure its effect. Other workers (7) in the southern Appalachians found that the average 16-inch tree bore 700 acorns per year. Trees 24 to 26 inches in diameter had 2,000 acorns. Still larger trees had fewer acorns. Another source (34) states that oak trees may yield from 1/4 to 1 1/2 bushels of clean acorns each. There are 8,000 to 10,000 clean white oak seed per bushel, so this estimate is somewhat higher than the above.

Sound white oak acorns have a germination capacity of 75 to 95 percent. They germinate in the fall soon after they drop. Acorns do not require any pretreatment for germination in the nursery. Germination is good when the temperature is about 65° F. during the day and about 50° F. at night. But for germination tests 86° F. for daytime and 68° F. for night are recommended (34). When the moisture content of the embryo falls to less than 50 percent of the dry weight, viability is greatly reduced. Hence a cover of litter on the ground soon after the acorns fall is important. This usually occurs in forest stands because leaf fall continues for some time after acorn fall.

In one study (7) less than 40 percent of the acorns produced were fully developed. And only 46 percent of these mature acorns were sound: 30 percent were damaged by insects, and 24 percent damaged by animals. Thus, of the total seeds produced, only about 18 percent were sound and fully developed. In a Missouri study (4) only 14 percent of the mature acorns were sound. However, some of the damaged acorns will germinate if the embryo is not damaged. Many acorns are destroyed after they reach the ground. Light crops are usually completely destroyed by insects and animals, so that seedlings are produced mostly during years of heavy crops.

Seed dissemination is accomplished chiefly by squirrels, gravity, and wind. Except for seed transported by squirrels, the seeding range is small. Widespread reproduction must depend on large numbers of seed-bearing trees.

Vegetative Reproduction

Young white oak trees sprout prolifically and vigorously when cut or badly damaged by fire. This ability to sprout is retained in trees up to at least 80 years of age (35). Much of the second-growth white oak has originated from sprouts following cutting or fire. In general, pole sprouts of low stump origin and seedling sprouts are about as good as trees from seed. Sprouts originating high on the stump are likely to have heartwood decay. Frequent fires and continual grazing of seedlings often result in the formation of root "stools" under the ground surface. Subsequent protection often results in abundant reproduction made up chiefly of sprouts from the stools (19). Underground root stools apparently also develop in the absence of fire and grazing, usually in the shade of the overstory trees. Opening of the stand by cutting results in the rapid growth of the seedling sprouts present. These stool sprouts are usually free from decay. A survey in Missouri showed that 57 percent of white oak reproduction was composed of sprouts. The white oak seedling sprouts develop from old buds, first formed on 1-year stems that have remained dormant.

Seedling Development

After acorns germinate in the fall, growth of the radical continues until interrupted by cold weather. White oak acorns, moreover, are capable of replacing broken radicals on freshly sprouted seed (14). In the spring the seedling develops a strong taproot, commonly more than a foot long and 1/4 to 1/2 inch in diameter.